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Paper No.1

The potency of THC in cannabis products

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Foreword

The core task of the NACD is to advise Government about the prevalence, prevention, treatment and consequences of problem drug taking in Ireland. In developing such advice the NACD reviews and evaluates published literature and data but more usually it commissions external research on the range of issues covered by its remit. The results of those studies are published when they have been considered by Government.

In the course of these studies the NACD may obtain information and/or data which might not be included in the final report. This material could for example, explore methodological issues pertaining to a particular topic. It could also derive technical or scientific material which might not be of immediate interest to policy makers but which might be interesting to researchers or workers in the drugs area. The NACD has decided to make these materials available to a wider readership through a Working Paper Series to be published on the NACD website.

The first paper in the series deals with the potency of various cannabis products on the Irish market, in terms of its content of the main psychoactive component THC (short for Tetrahydrocannabinol). The NACD hopes to update the data in this report on a regular basis given the increasing international concern about rising THC levels particularly in herbal cannabis of the “Skunk” or “Weed” variety. Allied to the increased levels of THC in these varieties is the absence of a second key chemical called CBD which seems to block some of the effects of THC on the brain.

Accurate analysis of the levels of these natural chemicals in cannabis drugs is a time-consuming and technically complex process. The NACD wishes to thank Dr Sheila Willis, Director of the Forensic Science Laboratory and her staff for agreeing to undertake the analysis. In particular we wish to acknowledge the support of Dr John Power for the work. We are also deeply indebted to Ms Colette Arnold, the author of the report for her excellent analytical skills which underpin the report.

Dr Des Corrigan
Chairperson
November 2011



1. Introduction

The illicit products produced from the cannabis plant such as dried plant material, commonly known as ‘grass’ or ‘marijuana’ and the resin secreted by the plant, commonly known as ‘hash’ are known to be the most highly abused drugs in the world. The increase in potency of the psychoactive ingredient of these products, Δ^9 -tetrahydrocannabinol (THC), is of much concern in many countries. This increase is thought to be attributed to hybridisation of different varieties of the plant and also a better understanding of the best cultivation practices to increase the THC content whilst the plant grows. Most of the cannabis products seized by An Garda Síochána in Ireland are thought to be imported from countries where it is specifically grown for exportation, however, surges in cannabis cultivation here in Ireland has become a major problem in recent times, this will be discussed below. The figure below shows that in the last decade cannabis resin was the most commonly seized drug in Ireland.

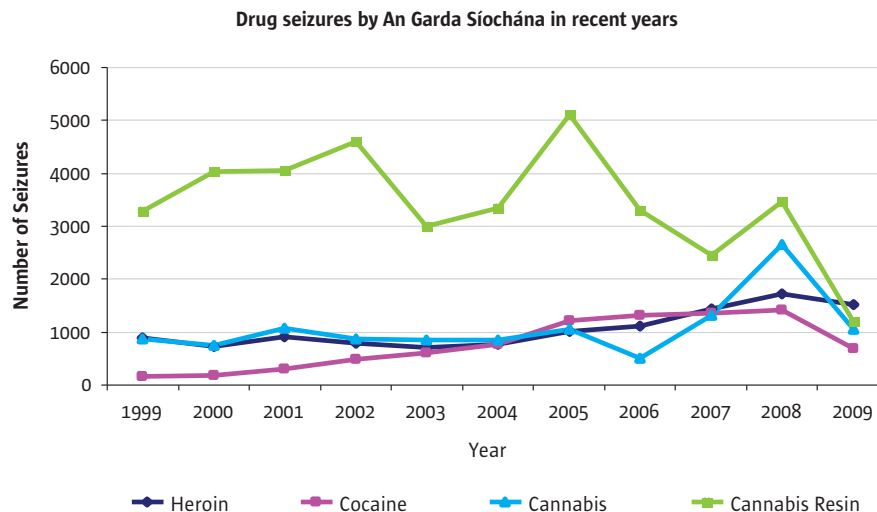


Figure 1: Recent drug seizures in Ireland. Compiled from figures retrieved from An Garda Síochána Annual Reports [1] (Figures in above table include both Garda and Customs seizures).

1.1 Cannabis resin

The resinous secretions of the cannabis plant can be collected to form slabs of cannabis resin commonly known as “hash”. Traditionally, this product has a high THC content as it consists of finer plant material and the resinous secretions of the epidermal cells of cannabis leaf and flowering regions. This product appears as loose or compressed sticky brown powder depending on the methods by which it was produced. The production of cannabis resin is found in two main regions of the world, Eastern Mediterranean countries and South Asian countries [2].

In Mediterranean countries, the resin is collected by threshing. Threshing the material against a wall separates the resin and fragmented leaves from the plant. The material is then sieved to remove seeds and larger parts of the plant. The fine sticky powder is then compressed into slabs on which sometimes a logo is imprinted. In Eastern Mediterranean countries, the material may be packed in cloth bags before compression but the most commonly presented package is North African resin, which are usually wrapped in cellulose before compression [3].



In Asian countries, the plants grown contain high resin content, so much so they are sticky to touch. The resinous material is collected by rubbing fresh plant material in the palms of the hand or by rubbing the sticky parts of the plant on rubber sheeting. Sometimes one may even wear rubber or leather clothing and walk through a field of cannabis plants to collect the resin. The powder is then pressed through sieves as above. It is stored for months in a leather bag. After which, it is exposed to sunlight to melting point after which it is kneaded until it is a suitable consistency to be compressed into slabs [3].

Along with the advanced methods of indoor cultivation, other less traditional methods to separate the resin from the plant material have been developed [2]. A “pollinator” device, similar to a domestic tumble dryer, lined with a fine net and plastic is filled with deep-frozen flowering and fruiting cannabis plant material. Rotation of the pollinator causes the THC-bearing parts to become detached and these pass through the net and are collected on the plastic as a fine powder. This fine powder is collected which can then be compressed into slabs.

The figures below show examples of the resin products and their different shapes and forms which are typical of imported resin in Ireland.

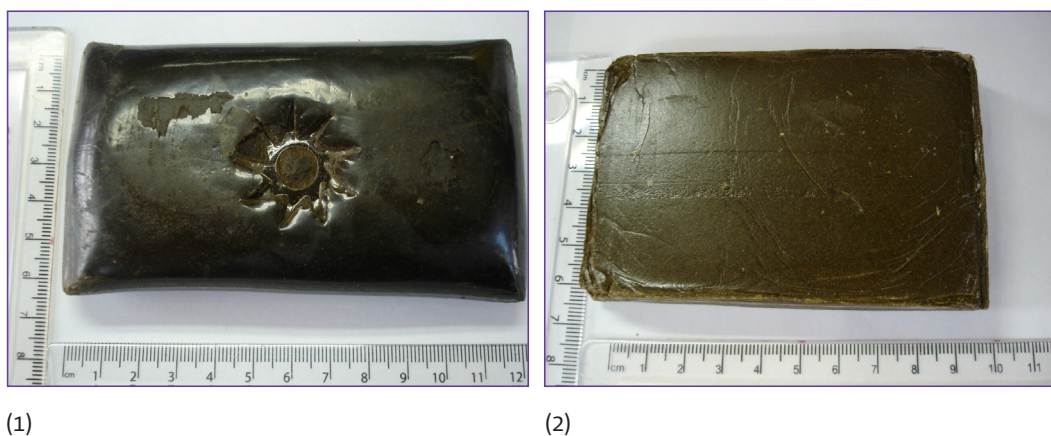


Figure 2: Example of a “soap bar” shaped (1) and a flat bar (2) of compressed resin material.

1.2 Herbal cannabis

Although it needs high temperatures, nutrient-rich soil, copious amounts of water and a lot of light, herbal cannabis is grown in most countries worldwide due to advanced techniques such as hydroponic systems i.e. growing cannabis in nutrient solutions rather than soil and ultraviolet lights available to the grower [2]. While it can be grown in any country in this way, a large importation market still remains within Europe and it is not known how much of Ireland’s market is due to home grown or imported cannabis. Herbal cannabis consists mainly of the flowering and fruiting tops of the female plant and has many slang terms but is commonly known as “grass”, “weed” or “marijuana”.



Male plants, known as staminate, are usually taller but less robust than female plants known as pistillate plants. Plants can grow as tall as 6 metres in height but a height of just over one metre being most commonly seen. It is a heavily branched plant, although this may vary due to cultivation method [4]. The major stalks are removed from the plant and the cultivated product is dried.

The breeding of these plants is most important to the THC content within a 'crop' of cannabis [2]. Cannabis is very rarely grown from seed as cuttings (clones) from a single plant can be propagated and thus a large crop may be produced from a single plant [4]. Male plants are widely considered to have a lower THC content than female plants and therefore this plant is not often grown. In fact, female plants that remain unfertilised throughout maturity have the highest THC content, these plants have no seed and the cultivation method that results in these female plants with no seeds is known as 'sinsemilla' (Spanish for "no seed") [5]. Much of the imported cannabis plant material seized in Ireland is of this type.

The THC content varies depending on the plant part – 10-12% in pistillate flowers, 1-2% in the leaves, 0.1- 0.3% in stalks and less than 0.03% in the roots [2]. It is this reason that only the flowers and leaves are sold to the illicit market. Herbal cannabis product also known as "marijuana" is mainly presented to the laboratory as dried leaves and flowers and can be seen in a number of different forms e.g. loose flowering top material, compressed slabs of plant material or ground up flowering tops and leaf material. Female pistillate flowers and leaves are shown in the main illustration and also the left-hand bottom corner in Figure 3 below. The figure also shows the seed of the cannabis plant.



Figure 3: Flowering plant and seeds [6].



1.3 Cannabis cultivation in Ireland

Although Ireland has not got the climate to grow these plants outdoors, they can be grown indoors using hydroponics and ultraviolet light equipment. The discovery of multiple large operations of so called ‘cannabis factories’ have been reported by An Garda Síochána in previous years, seizures with approximately 1000-2000 plants have been found. This increase is represented in the figure below, compiled from An Garda Síochána official annual reports. However, to date there has been no research into the trends of the potency levels of THC in homegrown or imported varieties of these cannabis products in Ireland.

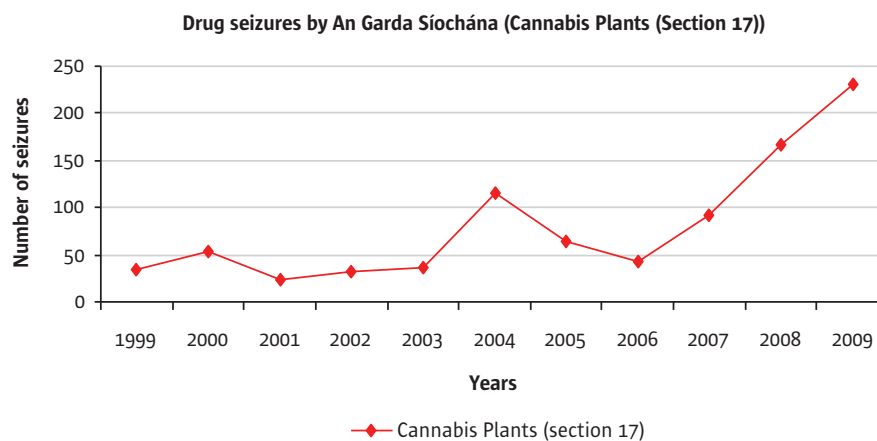


Figure 4: Recent increases in seizures under Section 17 in Ireland. Compiled from figures quoted in An Garda Síochána Annual Reports [1].

1.4 Chemical constituents of cannabis products and their health implications

Cannabis contains a unique set of chemical constituents known as the cannabinoids. To date, over 400 compounds have been isolated from different parts of the cannabis plant, with approximately 60 of these belonging to the group of cannabinoids [7]. Of the cannabinoids, the main psychoactive constituent is Δ^9 -tetrahydrocannabinol (THC). Two other important cannabinoids are cannabinol (CBN) and cannabidiol (CBD). Sources of these neutral cannabinoids in cannabis plant material are the cannabinoid acids that are formed in the plant but are later decarboxylated to yield the better-known cannabinoids [8].

Besides free THC, the cannabis plant material also contains Δ^9 -tetrahydrocannabinolcarboxylic acid (THCA). THCA is the most important precursor acid, which converts into the psychotropically active THC when heated, this occurs by a simple decarboxylation when cannabis products are smoked [9]. Thus, the amount of THC available to be consumed by the user increases upon heating. The quantity of THC in resin and cannabis plant materials has come under investigation over the last few years as its concentration has been rapidly increasing in previous years [5, 10]. This is of much concern as a recent study has shown that there is a higher risk of psychosis in those who smoke high-potency cannabis products [11]. Whilst it is the high THC and frequency of use of these products that may



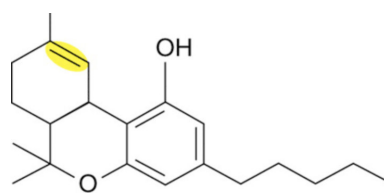
cause psychotic episodes, it is also thought to be attributed to the amount of CBD or lack thereof, in these products, as CBD is thought to decrease the effects of THC when ingested together.

A fact to consider is that CBN does not exist in freshly and carefully dried cannabis plant material. It is thought that its presence in samples comes from the degradation of THC. It is possible to estimate the age of a given plant sample on the basis of its THC and CBN content, assuming storage was carried out at room temperature. THC appears to degrade at a higher rate for the first year than for subsequent years [2].

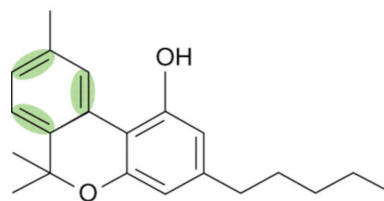
1.5 Cannabinoid analysis

The purpose of this study is to analyse cannabis products to establish their THC content. As mentioned already, the THC content of these products has risen in previous years and monitoring this has become more important to European authorities. This study and sequential studies will allow for a base line of the THC content in cannabis products to be established and for a comparison of future results to be made.

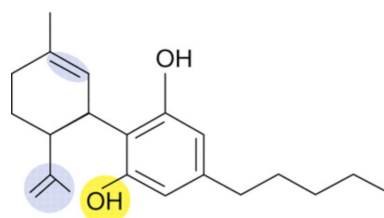
The structures of the 3 cannabinoids of importance in this report are shown in Figure 5 below. These are THC, CBN and CBD.



Δ^9 -Tetrahydrocannabinol



Cannabinol



Cannabidiol

Figure 5: Structures of the 3 main cannabinoids [12]



The use of gas chromatography (GC) to separate the cannabinoids is widely established [2]. Gas chromatography is a chemical method that uses heat to separate the components of a mixture, thus separating the mixture of THC, CBN and CBD collected from cannabis samples. However, decarboxylation of THCA to THC when using the heat of the GC method is suspected to be incomplete [9]. However, other authors that investigated other methods for THC analysis along with GC did not report this [13, 14], although at the time this work was carried out, the calibrants for quantitation of THCA may not have been available or too expensive to allow for these analysts to investigate this [9]. THC and THCA may be quantified separately using GC, however, this requires a time-consuming derivatisation step using N-methyl-N-trimethylsilyltrifluoroacetamide (MSTFA) [15].

Instead, GC can be used to quantitate the “Total THC” content, a combination of THCA and THC, of cannabis products as THCA has shown to decarboxylate to THC in the inlet port [9]. This method to determine the “total THC” is used by many forensic laboratories across Europe. Although GC has proven to be an effective, rapid simple technique, it can be questioned whether THCA is fully converted to THC on the liner upon entrance of the sample into the system. This has been considered previously [2].



2. Methods

A number of samples were collected from seizures submitted to the Forensic Science Laboratory by An Garda Síochána during the months of October 2010 to the end of December 2010. The seizure location was considered when collecting these samples to ensure a distribution across the country of Ireland.

2.1 Cannabis herb samples

On receipt, all seizures of plant material used to generate this report were identified as herbal cannabis material by the laboratories own accredited methods for the analysis of cannabis products. A sub-sample of the seizure was then removed for the quantitation of THC in that seizure. Herbal cannabis is a non-homogenous product and therefore a sub-sample may not be indicative of the highest THC content of that seizure. However, due to the destructive manner by which the sample is prepared the majority of the seizure must remain intact for production in court, where necessary and thus a random sub-sample was thought to give the best indication of the THC content of the seizure.

As mentioned in the introduction, the highest THC content is found in the female flowers, so all samples were prepared for quantitation of THC by removing as much stalk and leaf material as possible, as recommended by UNODC recommended methods [2]. Many other laboratories worldwide would use this method e.g. [16] meaning a comparison with our results is valid for this study. The female flowers were then ground into a fine homogenous powder using a mechanical grinding device and sieved to further remove small particles of stalk material from the sample.

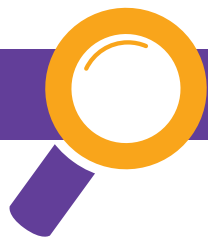
2.2 Cannabis resin samples

As for cannabis herb samples, all brown substance received as suspected cannabis resin seizure were first identified as cannabis resin by our accredited method before inclusion in this report. However, unlike the herbal cannabis samples which were sourced from seizures that were intended for supply, almost all resin samples used for this report came from smaller street samples thought to be used for personal use, as the number of seizures of cannabis resin for supply has fallen in recent times.

Cannabis resin is expected to be more homogenous than cannabis herb samples as it is a compressed powder, however, the outer surface has lower THC than the inner sample due to atmospheric oxidation of THC when in storage. The oxidation leads to a darker appearance in the outer layer and a breakdown of the THC in this layer (as it is exposed to oxygen in the air). Some laboratories choose to use the whole sample for quantitation [16]. The samples used in this study need to be preserved as much as possible for presentation in court, so the full sample was not analysed. Instead, a number of samples were removed from the inside of the original sample. Due to the fore mentioned oxidation, the external layer of sample was removed before these samples were taken.

2.3 Chemical analysis

Further sub-sampling of each sample allowed duplicate samples to be prepared in each case sample to ensure homogeneity of the sample. Both samples were then extracted into ethanol containing an internal standard – clomipramine. The total concentration of THC (THC and THC acid) was then determined using the internal standard method on a gas chromatograph coupled to a Flame ionisation detector.



3. Results

In total, 20 samples were analysed – 10 cannabis herb samples and 10 cannabis resin samples. These samples were all seized in different parts of the country. The figures in Table 1 and 2 represent the %THC extracted from the sub-samples of the seizures. These values are typical of the %THC content of both cannabis and cannabis resin seen in another study performed in Ireland over the last year [17], although samples of cannabis herb with almost 18% THC and cannabis resin with 8% THC have been seen. A CBD indicator column is also present in the tables to give an indication of the CBD content of all samples.

As all cannabis herb samples used for analysis were thought to be intended for sale and supply, it may be possible to indicate the source of these samples. In some cases the original description of the packaging in which these samples were found may indicate whether the sample was imported into the country and these are described as such in Table 1. However, in some cases the investigating garda has brought the samples directly from cannabis factories here in Ireland and these are marked as a cultivation in Table 1.

Table 1: %THC in cannabis herb:

Occurance date	Location	Description of item	% THC	CBD Indicator*
22/10/2010	Limerick	Suspected import	5.03	n/a
25/10/2010	Cork	Suspected import	5.74	med
14/11/2010	Tallaght	Suspected import	13.34	very low
03/11/2010	Tipperary	Suspected import	3.96	n/a
01/12/2010	Ronanstown	Suspected import	4.07	very low
03/11/2010	Fermoy	Suspected import	4.42	very low
13/10/2010	Dundrum	Suspected import	8.74	med
01/10/2010	Crumlin	Suspected import	6.26	low
05/09/2010	Bandon	Irish cultivation	16.39	very low
07/09/2010	Bandon	Irish cultivation	11.39	very low

* The CBD Indicator gives an estimation of the content of CBD in the sample (N/A = none, very low = <0.5, low = 0.5% - 1.5%, med = 1.5% - 2.5% and high = 2.5% - 3.5%)

Even though the cannabis resin samples used for this study were all small street seizures and not full bar samples, it is easy to identify the type of sample seized by the shape and colour of the sample. Light brown coloured samples which are almost dusty in texture usually originate from the flat bar type and are indicated as this type in Table 2. The other type of cannabis resin was the soap bar type which is also indicated in the table.

*Table 2: %THC in cannabis resin:*

Occurance date	Location	Description of item	% THC	CBD Indicator*
22/10/2010	Cavan	Soap bar	2.37	high
20/10/2010	North Circular Road, Dublin	Soap bar	1.13	low
02/10/2010	Tipperary	Pollen type	5.38	med
16/10/2010	Tallaght	Soap bar	<1	med
31/10/2010	Letterkenny	Pollen type	2.73	med
19/10/2010	Letterkenny	Pollen type	4.42	med
17/11/2010	Crumlin	Soap bar	<1	low
12/11/2010	Crumlin	Soap bar	1.56	low
31/10/2010	Clondalkin	Pollen type	2.75	med
26/11/2010	Fitzgibbon St., Dublin	Pollen type	3.99	med

*The CBD Indicator gives an estimation of the content of CBD in the sample (low = 0.5% - 1.5%, med = 1.5% - 2.5% and high = 2.5%- 3.5%)



4. Discussion

The amount of seizures of herbal cannabis is currently rising and a drop in the seizures of cannabis resin is also being noted by the Forensic Science Laboratory (FSL) through submission of seizures by An Garda Síochána. Figures from the FSL laboratory database show that the ratio of cannabis herb to cannabis resin was 1:1 in 2009, whilst figure for 2010 indicate that this will be 3:1 in 2010. This is consistent with that seen in other European countries [16]. A large increase in cannabis cultivation is also being seen. The seizures indicate that cannabis herb material seems to be in demand over cannabis resin. Is this because of a lack of cannabis resin or is it due to a rise in the THC content of cannabis herb?

Comparing the results displayed in Table 1 for THC concentrations in cannabis herb samples to a large-scale study of THC content in seizures in England and Wales in carried out by the Home Office in 2008, it was found that our results are very much in line with those published [16]. Whilst the Home Office study separated the cannabis herb seizures into 'sinsemilla' (samples without seed) and 'traditional imported cannabis' (samples with seed and traditionally not intensively grown), it was decided that due to a lack of traditionally grown samples for our study, this would not be considered and all our samples are considered and compared to 'sinsemilla' samples. However, our study did find that on a scale-to-scale basis Ireland has more low THC-containing cannabis as we found that 5 out of 10 samples contained in the region of 4-6% THC, whilst the Home Office only discovered that five samples out of approximately 200 samples fell in this region. The mean result for the Home Office THC content of Sinsemilla was found to be 16.2%, a very similar result to the highest THC-content sample found in Ireland's study at 16.4%.

In the Netherlands, where the policy on cannabis consumption is very different to Ireland and the U.K., a 2009/2010 study [18] found the average THC content of sinsemilla to be similar to that found in the Home Office study, with the average THC content being 17.8%. This study also found that Dutch hashish made from Dutch-grown cannabis contained a lot more THC with an average content of 32.6%. This fact supports our findings, in that home-grown varieties tend to contain more than imported cannabis.

Table 1 shows that there is little variance in the THC concentration in suspected imports. The highest value for THC content in the suspected imports found in Tallaght (13.34%), is out of line with the other values for suspected imports. A result like that may indicate that it was cultivated in Ireland or imported from a country with the ability to grow high THC containing plants. An important note is that the samples of higher THC content were mainly sample seized from 'cannabis factories' here in Ireland. With the number of cultivation type seizures growing in Ireland this may also need to be monitored more closely.

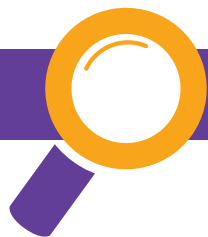
The results of our study are lower than those found in other countries, however, one reason for this may be the amount of time the sample spends in transit before it reaches our shores. This may be become more apparent in future work.



Comparing the results for cannabis resin to the Home Office study, the results of our study are more in line with that of seizures in England and Wales. More than half of the cannabis resin samples in the Home Office fell within 2-6% THC content [16], in our study this was true of 6 out of 10 of the cannabis resin samples. However, in the Netherlands [18] the average content of the resin samples was found to be 22%. This may be due to the fact that this resin is made from Dutch grown cannabis plants specifically grown with a high THC content for the purpose of making high THC containing resin material for sale in the coffee shops.

An important point to note from Table 2 is that the samples of highest THC concentration are those described as pollen type resin. This resin usually appears as a light brown rectangular block and is more powdery in nature than the typical soap bar blocks (Figure 2).

Although only a small sample set has been analysed in this study, further regular analysis will allow us to track the THC content in cannabis and cannabis resin seizures in Ireland in coming years.



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